Live Demonstration: Real-Time Calcium Trace Extraction from Large-Field-of-View Miniscope

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***Abstract*—We demonstrate a prototype system ACTEV for acceleration of calcium trace extraction from video captured by a large-field-of-view (LFOV) Miniscope at 22.8 fps. The ACTEV consists of an FPGA accelerator for the calcium image processing, an interface PCB for the data transmission and a GUI software for the user interaction. The FPGA accelerator takes a stream of 512×512 calcium images as input, executes motion correction, image enhancement and trace extraction from 1024 cells per frame with <1ms latency. The PCB transmits the raw calcium video and extracted traces to the host computer over an Ethernet interface. The GUI displays the received images and traces simultaneously for the user. The user can observe the motion corrected video and extracted traces from individual cells as the rat freely runs on a linear track.**

I. Description

Recent advancement in the miniaturized calcium-imaging device [1] enables neuroscientists to observe the activity of a large population of cells at a certain brain region of a mice or rat *in vivo* across days or weeks. Existing calcium image analyses mainly operate offline. There is a lack of guarantee for short and deterministic processing latency, which is critical for closed-loop feedback applications. We propose an FPGA-based prototype ACTEV to fill this gap. We demonstrate that the ACTEV can extract calcium traces from a maximum of 1024 cells from a cropped 512×512 video captured by the LFOV Miniscope in real time.

II. Demonstration Setup

Fig. 1 shows our demonstration setup, which includes: 1) The Ultra96 SoC platform, 2) the interface PCB, 3) the Miniscope data acquisition (DAQ) board, 4) the LFOV Miniscope and 5) the host computer. The implantable Miniscope is connected to the DAQ with a 1.5-m coax cable. The 66.67 MHz Miniscope clock, synchronization signals and 8-bit data are routed from the DAQ to the interface PCB through fly jumper wires. The customized FPGA accelerator on the Ultra96 SoC performs real-time calcium video processing [2]. It takes the Miniscope data from the PCB, carries out the motion correction and the image enhancement, and extracts traces from the video with sub-ms latency [3]. The Ultra96 SoC sends both the motion corrected video and the extracted traces to the host computer through the PCB over the Ethernet. The GUI running on the host displays and records the motion corrected video and calcium traces at real-time speed.

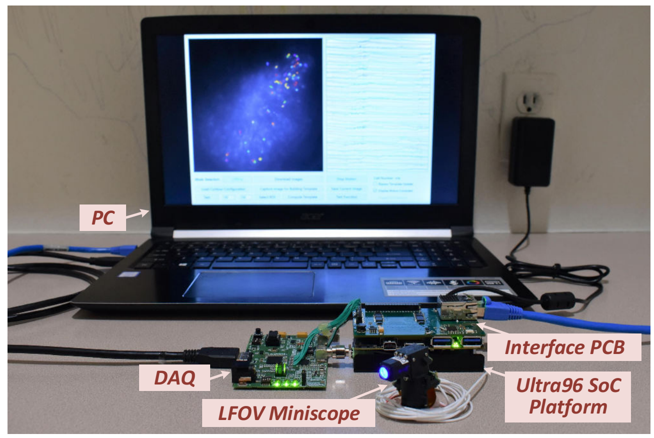

Fig. 1. Real-time processing of the replayed calcium video captured by the LFOV Miniscope (Link [4]).

III. Visitor Experience

We will present a recording for the real-time motion correction and trace extraction tested both on a rat and on a replayed calcium video from the FPGA. Visitors can operate the GUI under the replay mode, such as selecting a 128×128 subregion for the motion correction, turning on and off the motion correction to observe the difference, and switching on and off a group of cells for visualizing the real-time extracted calcium traces. Through these interactions, we expect visitors to get a better sense of the real-time performance of the ACTEV and understand its potential to enable the closed-loop feedback capability for the brain research based on Miniscopes.

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References

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